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Energy Efficient Third Generation Smart Electronic Module for A/C Filters

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Abstract

This project follows development of a smart electronic module with a custom designed sensor that can measure the condition of an A/C filter. This is done through multiple sensing techniques applied to make a 3-dimensional sensor that can generate signal of accurate information and process by algorithm of Arduino embedded system program codes to determine the condition and A/C's air flow energy efficiency of the filter.

Article body

INTRODUCTION

A study was conducted on the carelessness, and unawareness regarding A/C filters. Around the world, most individuals have shown that they did not check the A/C filter's condition as instructed since it was installed [1]. This disconnect from attention was the stem of this project for finding a meaningful practical solution. Dirty A/C filters have terrible effects, some examples include reduced circulation, reduced energy efficiency, and worst case scenario, the A/C system can experience freeze-up or overheating. Furthermore, unclean air can lead to many health related issues, like itchy skin/rashes, asthma, sinus problems and pneumonia, presented in Fig. 1, 2, and 3 for illustration [2, 3, 4, 5].

Fig. 1: Itchy skin and rashes.

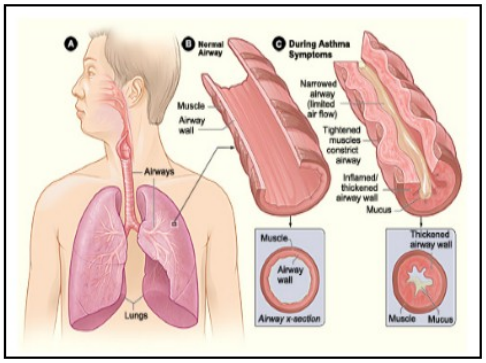

Fig. 2: Effects of asthma.

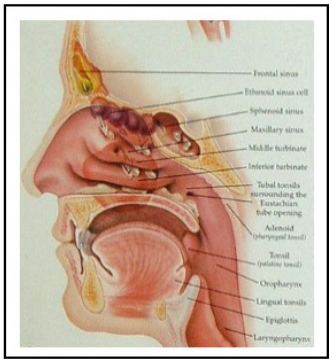

Fig. 3: Swollen sinus problem.

DESIGN METHODOLOGY AND THE 1ST GENERATION SENSOR

The sensor was initially was contemplated to be 'ionic-charge' sensitive, but through experimentation and research, it was found that different dust particles have different ionization levels. The 1st generation sensor, shown in Fig. 4, had photonic scattering to energize particles smaller 50nm, and a magnetic coil coated by electrostatic insulator material.

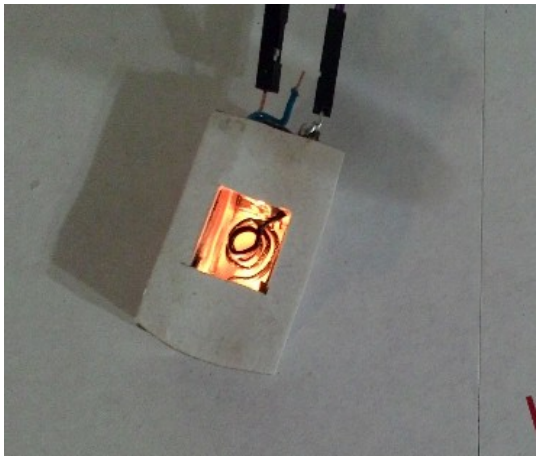

Fig. 4: An early prototype (1st generation) of the 3-D dust sensor in photonic operation when powered.

IMPROVED CONNECTIVITY AND THE 2ND GENERATION SENSOR

The 2nd generation sensor improved on the 1st generation sensor by circuit redesign and connectivity for adding a 3.5mm TRS (Tip, Ring, Stem) headphone type connector. This gave the sensor a better wiring option, easy access to smart module and attach-detachment feature. It is shown in Fig. 5.

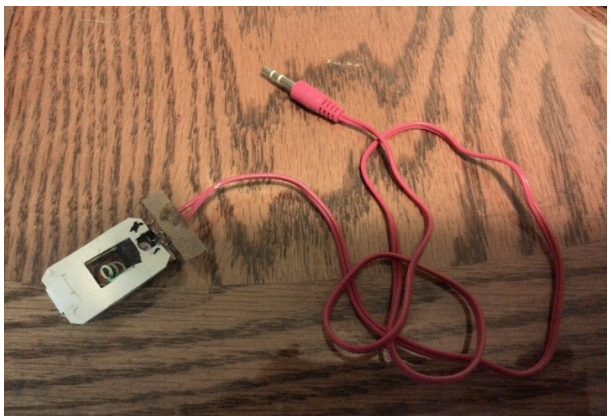

Fig. 5: The 2nd generation prototype is fitted with a 3.5mm TRS connection, having a better connectivity.

IMPLEMENTATION OF 3RD GENERATION SENSOR AND TESTING

The 3rd generation sensor expands on the 1st and 2nd generation, redesigned by not just being thinner, but being implementable into a filter. It enabled to all 3-D sensing functions required while placed inside a filter shown in Fig. 6. Two of the 3rd generation sensors were manufactured and attached to a miniature A/C system replica connected to the Arduino for processing its embedded custom program code [6]. Its output was displayed by an Android tablet, shown in Fig. 7, 8, 9 and 10.

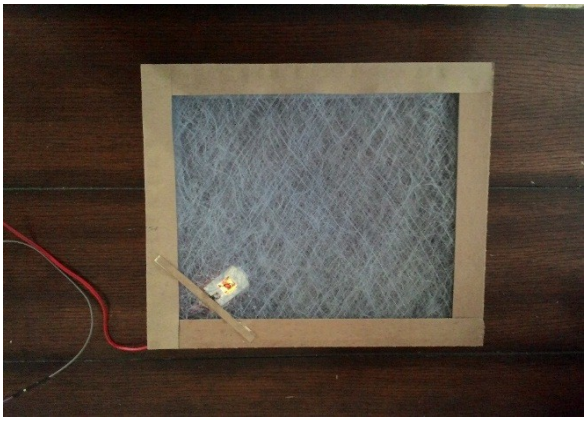

Fig. 6: Completed 3rd generation active 3-D sensor embedded in a disposable air filter.

Fig. 7: Fan blows air through the sensors on the opposite side (Fig. 8) and the information is displayed on the tablet (Fig. 9).

Fig. 8: Rear of the setup from Fig. 4 with two 3rd generation air filters collecting dust by the fan blowing air and the right side showing a lot of dust is already collected.

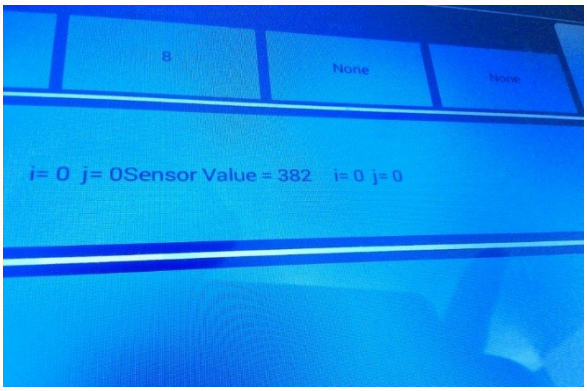

Fig 9: Tablet screen displaying value read from the 3rd generation sensor value by Arduino program codes shown in Fig. 7.

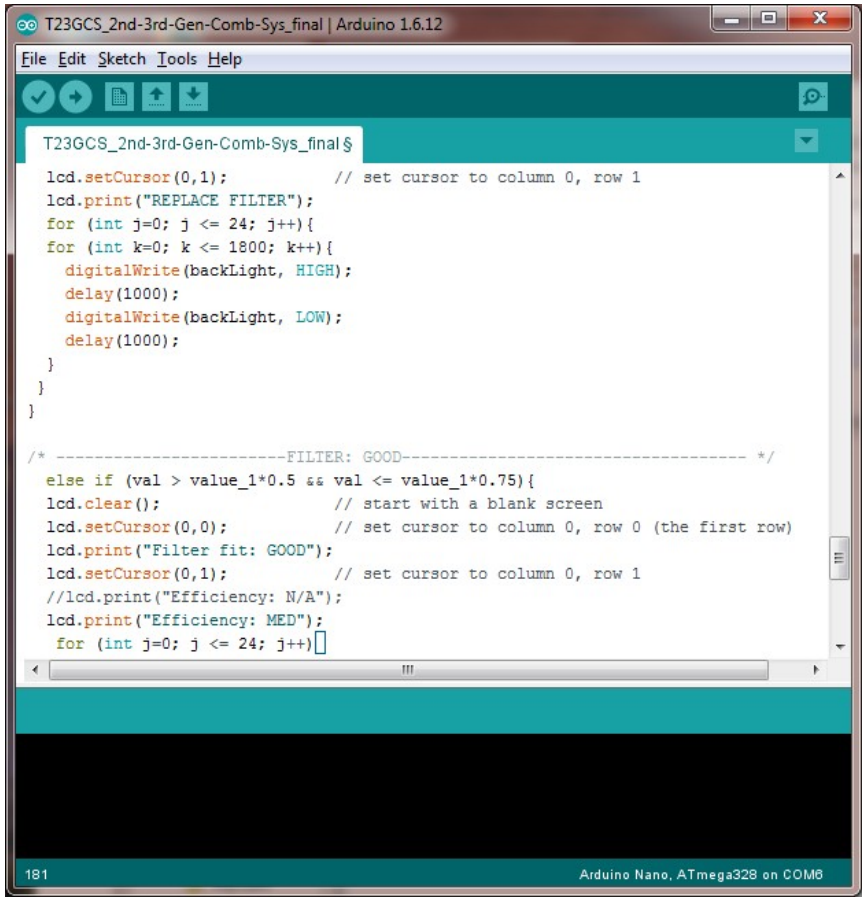

Fig. 10: A part of the Arduino program code of the 3rd generation sensor.

TABLE 1: The system values by Arduino read for different A/C filters and their respective efficiency

Filter Brands	Calibration	Max Efficiency		Med Efficiency		Low Efficiency	
and Types	Value	Max	Min	Max	Min	Max	Min
Filtrete Dust Reduce	438	435	430	325	320	217	215
Budget Fiber Glass	420	415	412	310	309	208	203
Dupont High allergen	430	427	425	318	317	213	211
Precisionaire Ez Flow	422	418	415	312	309	208	205

RESULTS AND DISCUSSION

This novel technique is applied in the Energy Efficient Smart Filter system that has been successfully designed and used in many different air filters. Energy bill can be reduced up to 15% by the smart electronic module of Arduino embedded system.

The 1st generation sensor used photonic effects on dust, a technique that dust particles less than 50nm become static or electrostatic for detection of dust accumulation by the sensor. Also a current flowing coil in the sensor also attracts Magnetostatic such particles, as hair follicles, for detection. The Sensor is a very low power state-of-the-art design that is guaranteed to consume less than 10mW. The 2nd generation sensor was improved upon the 1st generation sensor's circuit design and adding a 3.5mm TRS connection for better overall connectivity (and hence, better readings), hence establishing an attachable connectivity to the electronic module.

The 3rd generation progressed innovation using the 1st and 2nd generation techniques of the sensor that was implemented inside an A/C filter by significantly reducing its dimensions. It was the first successful design that was tested by flowing air through the filter for many days of collecting dust. The system performed very successfully to collect all data and thus determined the filter conditions (Table 1) to justify stages of air flow efficiency.

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